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SUBJECT: STUDY OF MODIFICATIONS TO THE FISSION PRODUCT DEVELOPMENT LABORATORY FOR ORNL RADIOACTIVE SOLID WASTE MANAGEMENT

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STUDY OF MODIFICATIONS TO THE FISSION PRODUCT DEVELOPMENT LABORATORY FOR ORNL RADIOACTIVE SOLID WASTE MANAGEMENT

S. J. Rimshaw and R. W. Schaich

ABSTRACT

The study estimates amounts and volumes of radioactive solid wastes generated at ORNL and the costs of proposed methods of handling these wastes in a central facility consisting of two modified existing buildings, one of which is designed for low-level waste (Building 3505), and the other for high-level waste (Building 3517). The estimated costs for modifying Buildings 3505 and 3517 are \$411,000 and \$850,000, respectively. The annual operating costs for ORNL solid waste management are estimated to be \$400,000.

Wastes are classified according to the type and level of radioactivity and the nature of the waste (combustible or noncombustible). It is proposed that low-level combustible waste of ~55,000 ft^3/year be reduced in volume to ~550 ft^3/year by means of incineration. High-level combustible solid waste reading >100 mrem/hr or containing >10 nCi of alpha activity per gram of waste is similarly reduced in volume by incineration from 6500 ft^3/year to 65 ft^3/year. The alpha-contaminated ash is placed in retrievable storage or shipped to a suitable site for final disposal. Encapsulation of high-level solid residues in an unleachable inorganic matrix can be carried out prior to final disposal.

Low-level, noncombustible solid waste of ~50,000 ft^3/year would be packaged for land burial. High-level, noncombustible, alpha-contaminated solid waste is generated at a rate of 4000 ft^3/year. This waste would be kept in retrievable storage or packaged for shipment to a final disposal site. Fragmentation techniques would be employed to reduce large, bulky items to small pieces which can be packaged. Decontamination facilities are provided to convert high-level solid wastes to low-level wastes which can be buried on site. Contaminated scrubbing solutions from the facility are disposed of by incorporation into a grout which is pumped into a fractured geological stratum ~1000 ft below the water table (shale fracture method of disposal).

INTRODUCTION

The considerable quantities of contaminated solid waste generated annually within ORNL are presently handled by burial in covered trenches and auger holes and by retrievable storage in vaults. Future limited storage space, the cost of retrievable storage, and the future potential requirement of the shipment of high-level waste to a permanent national waste storage site indicate the desirability of reducing the volume of contaminated solid waste. No ORNL facilities are presently available to perform volume reduction operations on contaminated solid waste.

A study was made during FY 1974 to assess the technical feasibility and cost of modifying an existing ORNL facility for solid waste volume-reduction operations. The facility chosen because of its availability and useful structural characteristics is the Fission Product Development Laboratory consisting of Buildings 3505 and 3517. The study also included a review of types and quantities of contaminated solid waste generated at ORNL and of volume reduction methods which can be applied to the ORNL waste. This report presents the result of the study.

CURRENT STATUS OF RADIOACTIVE SOLID WASTES AT ORNL

Classification of Wastes

Wastes are classified according to the type and level of radioactivity and according to the nature of the waste. AEC Immediate Action Directive No. 0511-21 dated March 20, 1970, requires interim storage and ready ability to retrieve high-level alpha-contaminated wastes, which consist of solid materials containing >10 nCi[1] of alpha activity per gram of waste, over a period of 20 years.[2] At ORNL this waste is segregated and sorted by the originator into combustible and noncombustible waste in labeled packages which can be identified by cross-reference to permanent records as specified by Pittman.[3]

Solid waste containing <10 nCi/g of alpha-emitting activity per gram of waste is classified at ORNL as high-level waste if the waste package reads >100 mrem/hr at the surface or if the waste is known to contain significant quantities of a pure beta emitter.[4] At present this waste is not sorted into combustible and noncombustible solids and is disposed of by burial in the ORNL Solid Waste Disposal Area.

Low-level solid wastes consist of packages which read <100 mrem/hr at the surface and which contain <10 nCi of alpha activity per gram of waste and no significant quantities of a pure beta emitter. At present this heterogeneou mass of waste is not segregated into combustible and noncombustible fractions, but is currently being buried in trenches at one of several sites in Melton Valley.

Composition and Volume of ORNL Solid Wastes

High-Level Alpha-Contaminated Solid Waste

The cumulative volume of high-level alpha-contaminated wastes stored retrievably[5] at ORNL was 17,000 ft^3 in June 1973 and ∿27,000 ft^3 in June 1974 and is projected to be ∿35,000 ft^3 in June 1975. Alpha-contaminated waste of this type is being generated at a rate of ∿8000 ft^3/year. Information on cumulative volumes of retrievable alpha-contaminated solid wastes stored in various kinds of containers in June 1974 is summarized in Table 1.

Table 1. Volumes of Alpha-Contaminated Solid Wastes Stored Retrievably in Various Types of Containers at ORNL in June 1974

Type of Container	Number of Containers	Volume of Solid Waste (ft^3)
Concrete Casks (7 ft high by 51 in. OD) (60 ft^3/cask)	190	11,000
55-Gallon Drums (stainless steel and black iron)	577	10,000
Steel Boxes (5 x 6 x 7-1/2 ft) (220 ft^3/box)	27	6,000
Total		27,000

If it is assumed that 50% of this waste is combustible, the total amount of combustible high-level alpha waste in retrievable storage is 13,500 ft^3 in June 1974 and is projected to be ∿17,500 ft^3 as of June 1975. Combustible alpha waste is being generated at the rate of ∿4000 ft^3/year.

Uncompacted densities of various wastes are useful in converting volume of solid waste to a weight basis. Thus, Wasling and Griffin[6] report the following values for the uncompacted densities of various wastes: 3.6 lb/ft^3 for paper hand towels; 7.2 lb/ft^3 for combustible wastes; 7.2 lb/ft^3 for a mixture of plastic, rubber, and cork; and 17.8 lb/ft^3 for noncombustible waste (metal and glass). Similarly, E. B. Fowler et al.[7] give the following uncompacted densities which were determined from a sorting experiment: 4.0 lb/ft^3 for paper and rags; 11.0 lb/ft^3 for rubber; 5 lb/ft^3 for plastic material; 32 lb/ft^3 for glass; and 18 lb/ft^3 for metal. From these data an average uncompacted density of 5.0 lb/ft^3 can be calculated for the combustible matter in a mixed ORNL solid waste containing 70% cellulosic material, 20% plastic, and 10% rubber. This value rises to ∿7.0 lb/ft^3 if no effort has been made to separate small items of glass and metal from the waste.

High-Level Solid Waste Containing Less Than 10 Nanocuries of Alpha-Emitters/Gram of Waste

2 The volume of waste containing <10 nCi of alpha emitters per gram of waste is assumed to be 5% of the volume of low-activity waste (100,000 ft^3/year) or 5000 ft^3/year. The 5% figure was derived by analogy from various categories of waste produced at the Cadarache Centre in France[8] and the Bhabha Centre in Bombay, India.[9] The composition of this waste is assumed to be the same as the composition of the low-level solid waste.

Low-Level Radioactive Solid Wastes

The volume of low-level waste generated per year has decreased from 122,000 ft^3 in 1972 to 117,000 ft^3 in 1973 and is estimated to be 100,000 ft^3 in 1974 and 1975.[5] The quantity of 100,000 ft^3/year is taken as a design basis in this conceptual study for handling low-level radioactive solid waste (designated as solid radwaste) in Building 3505 of ORNL.

At present ORNL disposes of its solid radwaste by burial in open trenches which are backfilled with excavated dirt.[10,11] Consequently, data on waste classification are scanty. Fortunately, data from other installations[12,13] are available by means of which it is possible to classify the solid radwaste into the further categories as shown in Table 2.

Table 2. Classification of Low-Level, Solid Radioactive Waste (Solid Radwaste) Generated at ORNL

Type of Waste	Percentage of Total Waste	Amount (ft^3/year)
Combustible	55	55,000
Small metal and glass	15	15,000
Large, hard objects	20	20,000
Concrete and soil	10	10,000

REVIEW OF WASTE HANDLING METHODS

Mechanical Methods of Volume Reduction

Mechanical methods are classified under compaction and fragmentation. These two methods are generally complementary. The choice of method will be determined by the geometry, size, and hardness of the object.

Compaction

This technique is of greatest economic benefit where waste is transported away from the site for final disposal. However, ORNL has its own burial ground and would use compaction to a limited extent, primarily for alpha-contaminated wastes which could not be decontaminated below the limit of

10 nCi/g. One of the shielded cells in Building 3505 can be used as a ventilated enclosure for housing a small compacting unit. The characteristics of compacting units are described by Walton,[2] and Hempelmann and Krause.[11]

Fragmentation

Fragmentable wastes include glove boxes, hoods, contaminated shielding plugs, pile-irradiated loops, ovens, control rods, and highly contaminated pieces of equipment from dismantling operations. Such equipment is of unusual size and is awkward to transport if not reduced in size. The contaminated items are frequently decontaminated before being cut up. A sealed waste-handling area has been designed and put into operation at Harwell where operators wearing pressurized suits operate various pieces of fragmenting equipment such as a plastic shredder and a glass crusher.[14] Fragmented wastes can be loaded out of the sealed contaminated area into standard size drums whose open tops are sealed into soft rubber rings by hydraulic pressure exerted by the drum carrier acting on the drum from below. In this way the drums are removed with the outer surfaces being free of significant contamination.

A cabin consisting of bolted metal panels is provided at Saclay for cutting contaminated metal.[13] Operators work in pressurized suits at a ventilated cutting table serviced by a roller conveyor. Electric arc cutting is preferred to cutting with an oxyacetylene torch to limit contamination spread. Sectioning by plasma torch is practiced at the Marcoule Centre (France) with water acting as a shielding material and contamination absorbent. There will be space available for installations of this type in Building 3505.

Various methods of cutting or shearing hard objects are reviewed by Pradel.[13] Circular saws and abrasive cutting wheels must be used with caution, especially if run at high speed, since they produce large amounts of radioactive aerosols. The danger of fire from incandescent particles must also be taken into account when working with metals. These operations must be performed under containment conditions. The chain saw has been used to cut up filters, but the large amount of fibrous scrap produced from the cutting operation must be confined in a glove box.[15] The pieces of combustible filter material are packed into paper bags and burnt. The outer wooden frame is also cut into pieces which are burned. Absolute filters frequently contain corrugated aluminum foils to hold fiberglass filter mats. These noncombustible filters can be cut with chain saws and compacted.[15] Pneumatic or hydraulic shearing machines can section pipe having a diameter up to 4 in. or solid bars about 1 in. in diameter.[13] No radioactive aerosols are produced in this operation, but the blades wear out and must be replaced rather frequently. Reciprocating saws are used for cutting long solid metal pieces.[13] The cutting speed is slow. Production of radioactive aerosols is eliminated by spraying with a liquid.

The Harwell Centre (United Kingdom) has a machine which shreds plastic material both to reduce the volume of waste and to prevent its reuse.[13] Small amounts of plastic can be burned when mixed with larger amounts of cellulosic materials. Burning is preferred to shredding when disposing of moderate amounts of plastic materials.

Incineration

Kinetic Thermal Combustion

Kinetic thermal combustion involves the continuous addition of fuel to a flame with continuous removal of thermal combustion products. Incineration of radioactive solid wastes by kinetic thermal combustion has been reviewed by Lennemann,[16] where it is indicated that incineration systems developed by AEC contractors do not operate satisfactorily and are expensive to build and maintain. This study briefly reviews the characteristics of incinerators which are required to overcome some of the deficiencies covered in Ref. 16.

Soot Control. An analysis of incinerator experience indicates that many serious problems plague the performance of these systems. Inadequate design or operation of the incinerator is generally blamed for incomplete combustion of solid waste, but a closer look at the combustion process indicates that soot formation is an inevitable concomitant of combustion. It should be noted that soot is produced industrially by burning a hydrocarbon in an oxygen-deficient atmosphere and this atmosphere can occur locally with partial air mixing.

Rather large amounts of soot are produced in the operation of an incinerator. Thus, the well-run incinerator at Marcoule, France,[17] which burned alpha-contaminated solid wastes reports the production of 350 lb of dry soot and a considerable amount of wetted soot contained in 3800 gal of caustic solution during a campaign in which 29 tons of waste and 1160 gal of contaminated oil were burned.

Soot deposition seriously interferes with incinerator operation. In dry systems, fires are frequent and filter life is short. Thus, Rocky Flats (p. 14, ref. 16) reported frequent fires at the face of the HEPA filters because of the ignition of accumulated tar and soot. Eight filter units were replaced after each 1000 lb of waste was burned. Installation of a wet scrubber completely eliminated the filter fires and extended the life of the HEPA filters. Incineration projects at Mound, Knolls, Los Alamos, and Argonne have been discontinued[18] because of operational complexities and high costs of incineration as a result of uncontrolled soot deposition.

Karlsruhe reported a constant hazard of smouldering fires from soot deposited in bag filters, the necessity of expending a great deal of labor in keeping the bag filters open by shaking, and high operating costs because of the short life of the bag filters (3-4 days). With the introduction of ceramic candle filters made of silicon carbide the soot is trapped and burned to carbon dioxide[19] in place. This system of cleaning the flue gases improved the operational safety of the Karlsruhe plant, decreased costs, and simplified the operation. At present, however, this technological innovation for controlling soot deposition has not been widely adopted in other countries with the exception of Japan[20] who is using the same technology in a low-level radioactive waste incineration system.

Furnace Design. Conventional furnace design calls for the use of mild steel as a construction material, thick layers of insulating fire-brick, large volumes of excess air to carry off the heat of combustion, and minimum treatment of the off-gas. Yet in burning radioactive solid wastes, especially high-level waste, stainless steel and inconel should be used extensively as heat-resistant materials of construction to lower the probability of equipment failure as a result of high temperature.

Double-wall construction for cooling with water or air should be utilized to protect the furnace and its accessories such as the ashpit and the solids-addition chute. Thick layers of refractory insulation (12-24 in.) should be replaced by a few inches of insulation to reduce the equipment size.

Combustion gases should be cooled in a gas-to-gas or gas-to-water heat exchanger and recycled back through the flame after oxygen is added in order to complete the combustion reaction and to reduce the volume of gas that must be treated by scrubbing. High temperatures on the order of 800-1200°C are usually specified for completion of the combustion reaction. These temperatures are limited by the materials of construction. As pointed out above, however, incomplete mixing with air and a low residence time in the high-temperature combustion zone lead to soot production and incomplete thermal cracking of heavy tars. With recirculation any undecomposed organic compounds are again exposed to flame degradation. More importantly, the residence time in the flame is increased, and combustion is more likely to be complete. The volume of combustion gases is a factor of 5 less than with the use of ordinary air and no internal recirculation of combustion gases.

These changes from conventional furnace design should be investigated on relatively small prototype units burning 5-10 lb/hr of solid waste in order to optimize the design with minimum expenditure of funds.

Gas Scrubbing and Filtration. The combustion gases must be scrubbed to obtain high decontamination factors before release to the environment. Although HEPA filters are efficient in removing particulate activity, other radioactivities such as ^{35}S, ^{131}I, ^{106}Ru, and ^{137}Cs can pass these filters in gaseous form. Wet scrubbing also removes tars and soot, and thus protects the HEPA filters. Caustic scrubbing neutralizes corrosive halogen acids such as HCl and HF which are formed during the combustion of halogen-containing plastics such as polyvinylchloride (PVC) and teflon. Caustic consumption for neutralization of halogen acids is estimated to be moderate, about 1,000 lb of NaOH to neutralize the halogen acids from 300,000 lb of solid waste (60,000 ft^3) burned per year. The caustic waste would be disposed of by shale fracture.

Recommendations for Developing the Kinetic Thermal Combustion Method of Incineration. Considerable development effort and lead time will be required to perfect the art of combustion for solid radioactive wastes. Because of the high capital costs of incineration systems, experimentation is needed on small models burning 10-20 lb/hr. Space has been designated in Building 3505 for a low-level incineration system burning 50 lb/hr and in Building 3517 for a high-level incineration system burning 20 lb/hr. Costs for installing these incineration systems have not been estimated because of the many unknown factors involved in combustion. Final disposal of the incinerator ash will be by shale fracture or by shipment to a national disposal site.

Static Pressurized Oxygen Combustion

With the use of this technique which is described by Cox,[21] solid waste is burned in a closed container under static conditions with oxygen under pressu A full-sized Pressurized Oxygen Combustion (POC) unit having a capacity of 10.8 ft^3 was designed and built to burn a waste charge of up to 5.0 lb. The POC vessel was designed to withstand a pressure of 2500 $lb/in.^2$ and an inner wall temperature of 300°F. This vessel burned batches of waste cleanly with no problems of soot deposition. Most of the matter in the waste was turned into combustion gases with only a small amount of residue. However, on the eighth run the gaskets on the POC vessel failed, and the hot combustion gases were released with considerable damage to the vessel as a result of erosion and metal melting. It was planned to use the POC vessel in Cells 8 and 9 of Building 3517 to burn batches of high-level alpha-contaminated waste.

Redesign of the POC vessel to obtain better sealing and further development work on the combustion process would be required to demonstrate a suitable process for burning high-level waste. Because of the simplicity of the pressurized combustion process, the equipment is potentially adaptable for remote control operation.

Decontamination Methods

Decontamination facilities are essential in converting high-level solid wastes to low-level wastes which are satisfactory for burial. Scrubbing by hand with the use of simple chemicals is found to be the most successful method in decontamination work according to Steindler and Gerding.[22] Mechanical aids such as high-speed grinders must be avoided to prevent the spread of airborne, radioactive, particulate contamination. A low-speed mechanical descaler is used to remove paint from surfaces, as long as a wet mop head or a stream of water is used to prevent the formation of particulate matter. Hydraulic jet cleaning is frequently used within a cell to remove embedded activity from a surface. These operations are performed in a suitably designed decontaminatio area with operators working in pressurized airline suits made of polyvinylchloride (PVC) for visibility and for protection from radioactive aerosols.

Decontamination plays an essential role in the decommissioning and dismantling of excess facilities. J. A. Ayres[23] reviews the use of ultrasonics and soaking, scrubbing, steam cleaning, electrolytic and chemical methods for decontaminating large equipment items. At ORNL the waste decontaminating solutions are concentrated by evaporation and are incorporated into a grout for final disposal by shale fracture.[24,25,26]

A decontamination facility can also solve many of the problems associated with slightly contaminated articles, especially if these articles are bulky and expensive to replace. For example, heavily shielded carriers with time gradually become more contaminated and hazardous to operate. A place is required where these carriers can be disassembled, decontaminated and put back into service. Often a large piece of equipment must be decontaminated before it can be repaired. In this case, the repair operation represents a radiologi hazard because of the possible release or spread of contamination. An adequat decontamination facility can be used for emergency repairs on bulky items of contaminated equipment. Consequently, decontamination methods will be of great value in disposing of noncombustible wastes of large size. High-level and low-level decontamination facilities would be useful and desirable.

Miscellaneous Methods

The proposed low-level central waste handling facility can also handle various problem materials which involve contamination or chemical hazards and which can also be dealt with more efficiently on a collective basis. A number of these problem materials have been identified and are discussed below under disposal of plastic materials, lead melting, and disposal of sodium metal.

Disposal of Plastic Materials

Moderate amounts of plastic materials can be mixed with cellulosic materials and burned. R. L. Lines and E. M. King[27] have developed a method of reducing the volume of plastic materials in a hot cell by melting the plastics in a metal container surrounded with an electric heating mantle. Danger of fire is avoided by covering the can to exclude air. The radioactivity is enclosed in the resultant monolithic block of plastic and should be unleachable by water. This method is simple in operation and can be readily scaled up to a 30-gal size metal container. Low-level contaminated plastic materials may also serve as fillers which can be incorporated with other contaminated waste materials to prevent leaching of activity.

I. Larsen of the Danish Research Establishment at Risö, Denmark,[28] reports on an acid digestion process in which it is possible to destroy plastic materials at a rate of 15 kg/day by heating the materials in concentrated sulfuric acid at 250-260°C. All the equipment is either quartz or glass throughout the plant. The plant consumes about 15 kg of sulfuric acid and 20 kg of nitric acid per working day. Sulfur dioxide is lost during the night when the SO_2 recovery tower is shut down. Operational difficulties stem from a danger of breakage of the fragile glass equipment and from the occurrence of overpressure in the quartz reaction vessel. Recently this process has been proposed as a method of recovering plutonium from alpha-contaminated waste material.[29] Because of the complexity of the process this method of destroying plastic materials is not recommended for use at ORNL at this time.

Disposal of Contaminated Lead

Contaminated lead is melted in batches of 1000 lb at 450°C, and cast into 20-25 lb blocks.[13] Lead normally contains impurities which act as carriers of the radioactive contaminants. About 1% of the lead is skimmed off as a waste slag which is discarded. Ventilation is provided to protect operators against the risk of inhaling lead vapors.

Disposal of Sodium Metal

At present sodium metal is disposed of by dropping a 55-gal drum containing sodium metal into a water-filled quarry hole. Sodium reacts with water to produce NaOH and hydrogen gas. This reaction is practically irreversible, and the speed of reaction is so great that the time needed for complete reaction is determined chiefly by the mode of mixing the reagents. In disposing of sodium metal the reaction rate can be controlled by adding water as steam along with inert nitrogen or argon gas which dilutes the hydrogen gas and also serves to carry off some of the heat of reaction.[30] Immersion in alcohols can also be used to dispose of sodium metal.[31] The caustic produced from the reaction with sodium metal can be utilized in the incinerator off-gas scrubbers. Equipment for sodium dissolution can be set up in one of the smaller cells of Building 3505.

TECHNIQUES AND FACILITY FOR SOLID WASTE MANAGEMENT AT ORNL

Effect of Final Mode of Storage on Solid Waste Management

The criteria for the final mode of storage will dictate the specifications of the waste storage form and, consequently, will influence the design of equipment and procedures used in preparing the solid waste for final storage. Decisions have not been made on final modes of storage, especially for high-level wastes; consequently, a certain amount of flexibility in processing radioactive solid wastes should be provided.

The plan for the management of AEC-generated, radioactive wastes[3] calls for handling these wastes in a manner that will not endanger the health and safety of its employees or the public, that will not have an adverse impact on man's environment or on the ecology, and that will be accepted by the public. In addition, continuing efforts shall be made to develop and use improved technology that will reduce the quantity of radioactivity released to the lowest level below established standards to the extent technically and economically practical. The radioactive contamination of existing facilities is to be minimized, and steps are to be taken to convert existing contaminated facilities to beneficial uses while minimizing long-term surveillance and maintenance. Because of the high cost of packaging and shipping solidified, high-level radioactive wastes, potential methods for acceptable on-site, long-term storage must be investigated.

The strategy of implementing these objectives involves the use of land burial, decontamination, incineration, encapsulation, shale fracture disposal, or various combinations of these methods. For example, land burial is a relatively inexpensive method of disposing of low-level solid wastes, and ORNL possesses suitable sites for surface burial in controlled areas where geological factors have been considered in selecting the burial site. High-level solid waste in some cases can be converted to a low-level waste by decontamination and then buried.

High-level, beta-gamma solid waste that cannot be decontaminated or incinerated may be packaged in drums with a solid inorganic matrix such as polymer concrete.[32] If necessary, the filled drum is then centered in an outer drum which is filled with gravel and a vibrated polymer cement grout. This system has been used to package 95% of the solid radioactive waste generated by the Plutonium Production Centre at Marcoule, France.[33] This procedure will immobilize the activity in the polymer concrete and provide shielding while the drum is being transported. The drum can be buried in an auger hole at ORNL or shipped to a National Disposal Site. Tests on polymer-impregnated concrete show excellent resistance to water penetration and deterioration from abrasion and wear, but further leach tests would have to be run to prove its suitability as a barrier to the migration of radioactivity. Criteria would have to be developed for the amount of activity permitted in polymer-impregnated concrete.

Hydraulic fracturing of a stratum ∿1000 ft below the water table has been developed as a permanent means of disposal for radioactive wastes at ORNL.[24,25,26] Radioactive liquids are concentrated by evaporation, mixed with fly ash and cement, and pumped into the previously fractured stratum as a grout which sets to a solid containing the radioactivity 1000 ft below the water table. It is proposed that incinerator ashes and decontaminating solutions resulting from the operation of the solid waste facility be disposed of by shale fracture.

A small fraction of the radioactive solid wastes, primarily alpha-contaminated solids, may not be suitable for disposal by the above methods. These solid wastes can be put into retrievable storage or shipped to a National Storage Site for deep geologic disposal.[34] One of the main objectives of the central waste-handling facility will be to reduce this type of alpha-contaminated waste to a minimum by the combined use of decontamination and fragmentation methods.

Utilization of Fission Product Development Laboratory For Handling ORNL Contaminated Solid Waste

X

The centralized handling of all ORNL contaminated solid wastes can be accomplished at the FPDL by utilizing Building 3505 for low-level waste and Building 3517 for high-level waste. The volume and weight of radioactive solid waste; the type of waste, mode of treatment, treatment site, solid residues, decontamination and scrub solutions, and final disposal of waste residues are summarized in Table 3. Waste handling methods, and waste treatment sites are discussed below. The areas and cells of Building 3505 specified for the various operations are representative and are selected in accordance with the present internal arrangement of the facility. Upon definition of the exact sizes and types of equipment for the several operations, this arrangement might not prove to be optimum. Considerable internal modification might be required, and the arrangement of equipment might be different.

Table 3. Volume and Weight of Radioactive Solid Waste, Type of Waste, Mode of Treatment, Treatment Site, and Disposal of Waste Residues

Type of Waste	Kind of Waste	Volume (ft^3/yr)	Weight (lb/yr)	Mode of Treatment	Additional Treatment	Treatment Site 3505	Treatment Site 3517	Solid Residue (lb/yr)	Final Disposal	Comments
Low-Level	Combustible	55,000	275,000	Incineration	None	Cells B and C		11,000	Shale fracture	Caustic scrub solution to shale fracture
Low-Level	Noncombustible	15,000	300,000	Packaging	None	A		300,000	Land burial	
Low-Level	Noncombustible Large	20,000	100,000	Fragmentation	None	A		100,000	Land burial	
Low-Level	Noncombustible Soil	10,000		None	None				Land burial	
Low-Level	Noncombustible	2,000	10,000	Decontamination	None		Cell 1	10,000	Land burial	High-level waste converted to low-level waste by decontamination
High-Level	Noncombustible	500	5,000	Fragmentation	Encapsulation		Cells 1, 2,3,4, and 5	10,000	Land burial or shipment	Contains no alpha activity
High-Level	Combustible	2,500	12,500	Incineration			Cells 8 and 9	500	Shale fracture retrievable storage or shipment	Residual ash may contain alpha activity
High-Level (alpha)	Combustible	4,000	20,000	Incineration			Cells 8 and 9	800	Retrievable storage or shipment	Alpha activity is concentrated in ash
High-Level (alpha)	Noncombustible	4,000	40,000	Packaging			Cells 2 3,4,5	740,000	Retrievable storage or shipment	

85%

(12 16)

Low-Level Waste Handling in Building 3505

Building 3505 is 76 ft long by 64 ft wide by 15 ft high. It contains seven shielded cells with solid concrete or concrete block walls, 0.5 ft–2 ft thick. A floor plan of this building is presented in Fig. 1, and the dimensions of the various cells are given in Table 4. A canal 35 ft long by 6 1/2 ft wide (227 ft²) by approximately 13 ft deep lies to the west of Building 3505. Incoming waste would be surveyed, sorted, and stored in this canal. Cell Area A, a large area 19 ft by 21 ft by 18 ft high, is intended as a decontamination and fragmentation area. (400 ft²) Cells B and C are reserved for housing the incinerator and off-gas scrubbing equipment. Cells D, E, F, and G can be reserved for future installation of equipment for other specialized operations.

Table 4. Inside Dimensions of Cells in Building 3505

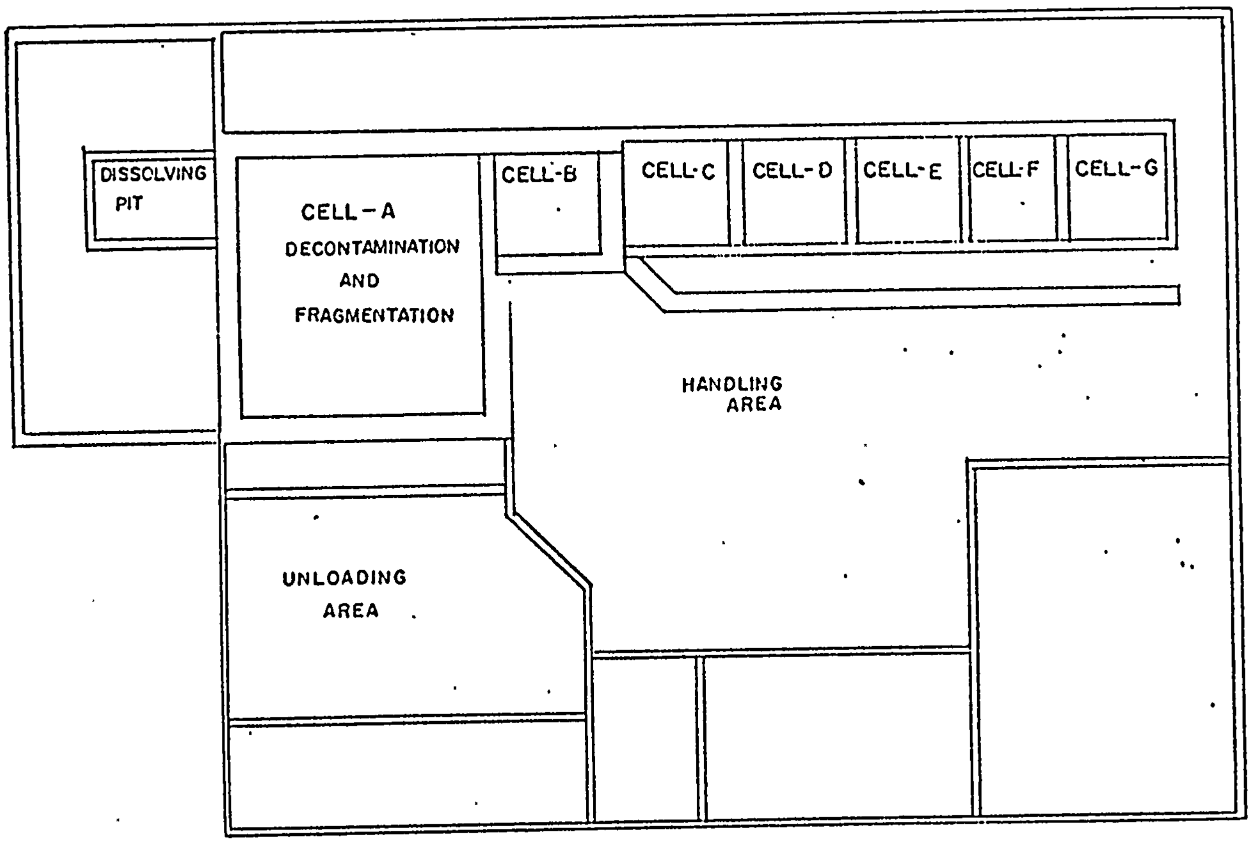
Structure	Length (ft)	Width (ft)	Height (ft)	Thickness of Concrete Walls (ft)	Comments
Building	76	64	15.5		
Canal	35	6.5	13		
Dissolver Room	25.5	33	15.5	0.5	
Dissolver Pit	9.5	6.5	9.5		14 gage SS lining
Cell A	19	21	18	2	14 gage SS floor lining
Cell B	8	8	30	2	14 gage SS floor lining
Cell C	8	9.3	30	0.67	14 gage SS floor lining
Cell D	8	9.3	18	0.67	14 gage SS floor lining
Cell E	8	9.3	18	0.67	14 gage SS floor lining
Cell F	6.5	9.3	17	0.67	14 gage SS floor lining
Cell G	8	9.3	17	0.67	14 gage SS floor lining

6300 ft²

Incineration of Low-Level Combustible Waste In Building 3505. The incinerator and gas scrubbing equipment will be housed in Cells B and C of Building 3505. Combustible waste will be collected separately from noncombustible materials in batch sizes not exceeding 2.5 lb or ∿4 gal in volume (5% of the hourly burning rate) which are fed to a 50 lb/hr incinerator. L. Silverman[18] indicates that the batch size fed to various incinerators is ∿5% of the hourly burning rate. Large amounts of plastic or rubber must be mixed with cellulosic materials for proper incineration.

$10\frac{3}{8}'' = 8\frac{1}{4}$

SQUAD CHECK											REVISIONS			
	CA	CP	EC	EE	EM	IE	MA	MD	PE	REV.	ZONE	DESCRIPTION	DATE	BY	APP



TOLERANCES UNLESS OTHERWISE SPECIFIED	
FRACTIONS ±	DESIGN
XX DECIMALS ±	DRAWN CS 10/29/74
XXX DECIMALS ±	CHECKED
ANGLES ±	SECTION
BREAK SHARP EDGES ___ MAX	DEPT.
REFERENCES:	DIVISION
	OPERATOR
	EQ T & I/MID
	SAFETY
ORDER NO.	FIRE PROT
W O.	NUC SAFETY
R IA NO.	AIR & WATER

UNION CARBIDE CORPORATION NUCLEAR DIVISION
Oak Ridge, Tennessee

FLOOR PLAN BUILDING 3505
FOR HANDLING LOW-LEVEL WASTE

SCALE $\frac{3}{32}'' = 1'$ SHEET OF

ORNL 3505 B-RD-2936

(18)

Combustible waste is generated at the rate of 55,000 ft^3/year with a weight of 275,000 lb/year at a density of 5 lb/ft^3. The residual ash will weigh ~11,000 lb (4% of the original weight), but the volume will be ~550 ft^3 (~1% of the original volume). Caustic consumption for the gas scrubbers will be ~1000 lb/year or 10,000 liters of 10 $\underline{N}$ NaOH. Caustic scrubbing solution and residual incinerator ash would be disposed of by shale fracture.

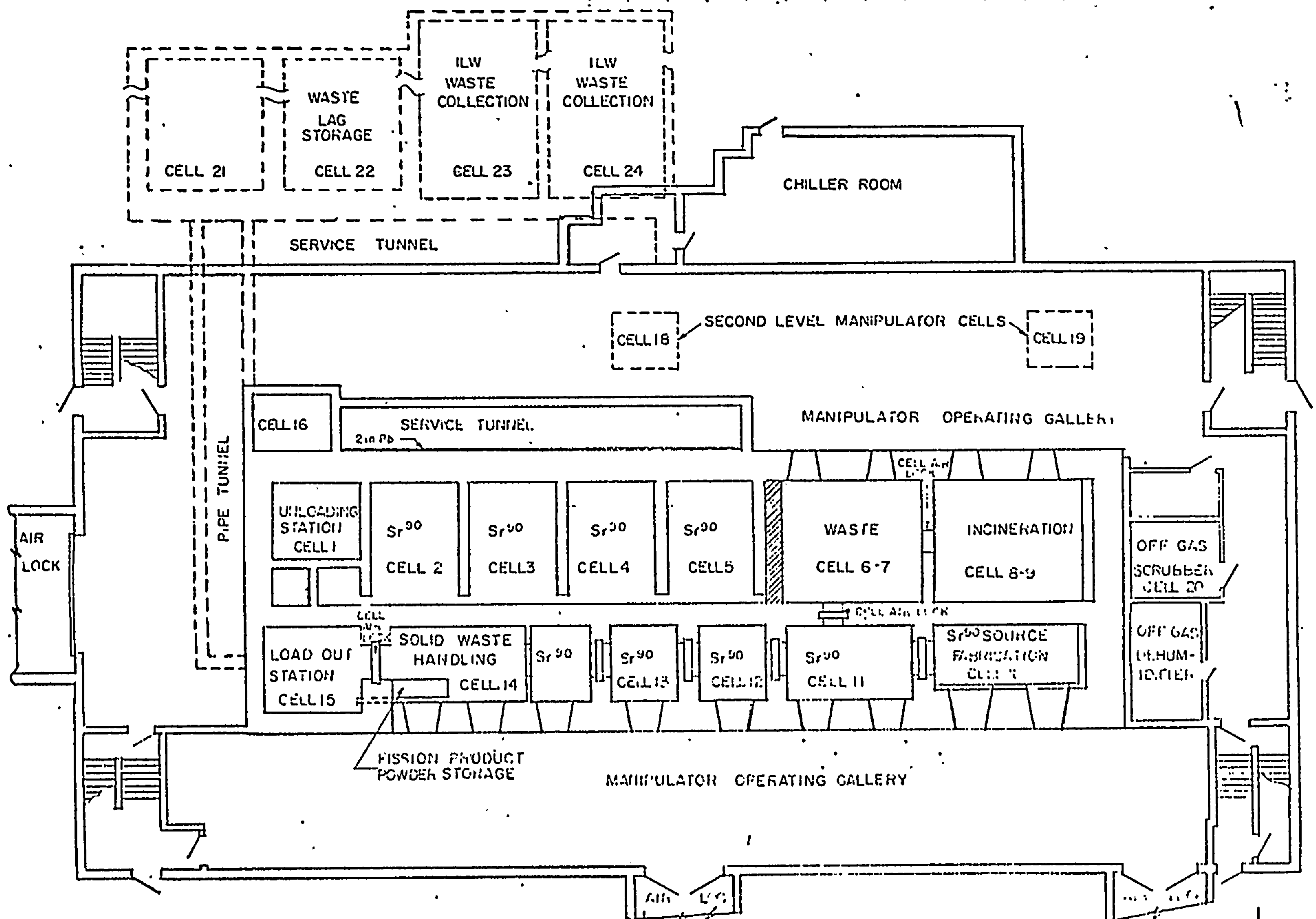
Treatment of Low-Level Noncombustible Solid Waste in Building 3505. Small metal and glass articles must be separated from combustible waste at the source. This simple sorting step can be accomplished at ORNL by having the collecting agency provide suitable types of containers for metal and glass. Large hard objects consist of glove boxes, pipe, discarded tanks and experimental equipment. After being surveyed, most of this material can be buried directly without treatment. It is estimated that 90% of the low-level solid waste at ORNL is so low in contamination that it can be buried in the ground after being surveyed to determine the level of activity. A small fraction of the low-level solid waste material may require decontamination before it can be buried. The amounts of low-level noncombustible waste as summarized in Table 3 are estimated to be 15,000 ft^3/year for small metal and glass items, 20,000 ft^3/year for large noncombustible objects, 10,000 ft^3/year for noncombustible soil and building materials, and ~2000 ft^3/year for high-level noncombustible waste converted to low-level waste by decontamination.

Specialized operations involving compaction, fragmentation, or decontamination can be set up in Cells D, E, F, and G.

High-Level Waste Handling In Building 3517

Description of Building 3517. A floor plan of Building 3517 is shown in Fig. 2. Combustible, alpha-contaminated solid waste in smear-clean combustible containers will be transported to Building 3517 in special bottom-loading waste casks (Fig. 3) designed to protect handling personnel and to contain the contamination during transport. The solid waste is transferred by airlock to Waste Handling Cells 6 and 7 and is incinerated in Cells 8 and 9. The existing Cells 6, 7, 8, and 9 will be rearranged to form two larger manipulator-operated cells which will meet the requirements for alpha containment. An airlock will be installed between Cell 6-7 and Cell 8-9 for waste transfer. Cell 19, a manipulator cell located on top of Cell 8-9, will be used to transfer out encapsulated cans of alpha-contaminated ash resulting from the combustion process. An airlock will be installed between Cell 11 and waste handling Cell 6-7 so that high-level, beta-gamma, combustible solid waste can be transferred to incineration Cell 8-9. A new transfer cask will be required to transfer alpha-contaminated solid wastes from contributing facilities to Building 3517.

Incineration of High-Level Combustible Waste In Building 3517. The combustible material will consist primarily of alpha-contaminated material which has already been segregated from noncombustible material in 1.0-gal batches and placed in retrievable storage. An incinerator burning 20 lb/hr could dispose of 60,000 lb of waste per year (~12,000 ft^3) on the basis of two-shift/day operation. This rate is great enough to process the combustible waste generated currently (~4000 ft^3/year) and part of the backlogged combustible waste (13,500 ft^3).



SQUAD CHECK									REVISIONS				
CA	CP	EC	EE	EM	IE	MA	MD	PE	REV.	ZONE	DESCRIPTION	DATE	BY	APP'D

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES ___ MAX

REFERENCES
DWG No. CRD 2073

DESIGN
DRAWN
CHECKED
SECTION
DEPT
DIVISION
OPERATOR
EQ T D I/M D
SAFETY
FIRE PROT
IND SAFETY

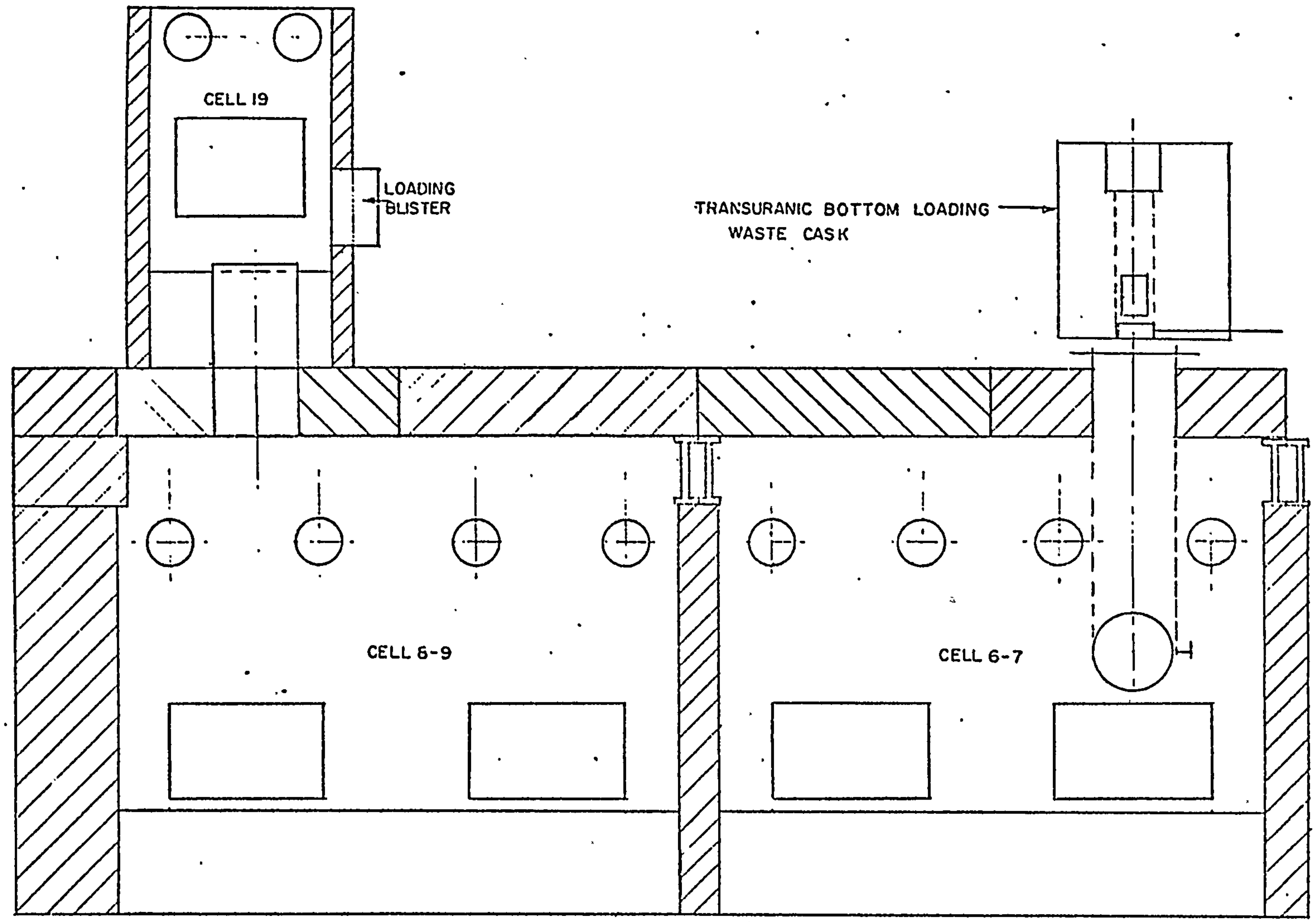
ORDER NO

UNION CARBIDE CORPORATION • NUCLEAR DIVISION
Operated for the Atomic Energy Commission under U.S. Government Contract W-7405 eng 26
Oak Ridge, Tennessee

ORNL HIGH LEVEL SOLID WASTE MANAGEMENT FACILITY

SCALE:
SHEET OF

CA	CP	EC	EE	EM	IE	MA	MD	PE	REV.	ZONE	DESCRIPTION	DATE	BY	APP'D



TOLERANCES UNLESS OTHERWISE SPECIFIED	DESIGN	
FRACTIONS ±	DRAWN CS	11/22/74
XX DECIMALS ±	CHECKED	
XXX DECIMALS ±	SECTION	
ANGLES ±	DEPT	
BREAK SHARP EDGES ___ MAX	DIVISION	
REFERENCES: DWG CRD 2917		
	OPERATOR	
	CO. T D I/MID	
	SAFETY	
ORDER NO	FIRE PROT	
W O.	NUC SAFETY	
D.M. No		

UNION CARBIDE CORPORATION • NUCLEAR DIVISION

Oak Ridge, Tennessee

ORNL SOLID WASTE MANAGEMENT

PROCESSAL CELLS

SCALE: NONE

SHEET OF

C -RD 2916

For an incinerator burning 20 lb/hr the batch size would be 1.0 lb or ~1.6 gal if 5% of the hourly rate is used as a factor. This incineration operation will be carried out in Cells 6-7 and 8-9 of Building 3517.

Incineration ash would be produced at a rate of ~2400 lb/year, if it is assumed that 4% of the combustible waste remains as a residue. This material can be packaged in welded cans for transport to a National Disposal Site, or it could also be disposed of by shale fracture. This waste ash could also be retrievably stored for subsequent recovery of alpha-emitting elements.

Treatment of High-Level Noncombustible Solid Waste in Building 3517. The volume of noncombustible solid waste is estimated to be 4000 ft^3/year for alpha-contaminated material, and 2500 ft^3/year for beta-gamma solid waste. The volume of the beta-gamma waste is assumed to be 5% of the volume of low-activity waste (100,000 ft^3/year) or 5000 ft^3/year with 50% of this material being noncombustible waste. Rather drastic chemical methods can be used to decontaminate a part of this noncombustible waste and thus promote this type of waste to low-level solid waste. Decontamination would be started in Cell 1 of Building 3517, and completed in Cell A of Building 3505 in order to derive maximum benefit from both high-level and low-level decontamination facilities.

Solid waste which cannot be decontaminated adequately can be encased in polymer-impregnated concrete for final disposal or shipment or sent to retrievable storage. Cells 2, 3, 4 and 5 of Building 3517 are adaptable for fragmenting and encapsulating high-level solid waste in a suitable matrix. The costs of modifying Cells 2, 3, 4, and 5 have not been considered in this study.

COSTS OF MODIFYING AND OPERATING A CENTRAL WASTE-HANDLING COMPLEX

Costs of Modifying Building 3505

The estimated costs of modifying Building 3505 for handling low-level solid wastes are presented in Table 5. These costs are primarily for structural modifications, repairs, and the addition of building services to put Building 3505 in operable condition. Equipment costs are not included because various types of solid waste-handling equipment are presently being investigated under other AEC programs, and final recommendations are not available. In particular, incinerator design for burning contaminated waste is in an early stage of development.

Table 5. Costs of Modifying Building 3505 For Handling Low-Level Solid Wastes

(Basis: FY 1974 Dollars)

Cost Item	Estimated Cost CPFF	ORNL*
Demolition (interior walls, piping, doors, etc.)	$ 12,000	$ -
Structural Modifications (replace flooring, seal openings, install new walls, repair roof, paint, etc.)	86,500	500
Building Services (steam, electrical, air handling, fire protection, water)	77,500	-
Outside Utilities	7,000	-
Labor Factor	29,000	-
Miscellaneous Costs (radiation factor, cleanup, service connections, etc.)	11,000	1,500
Indirect	67,000	-
Design and Engineering	-	50,500
Contingency (20%)	58,000	10,500
Total	$348,000	$63,000
TOTAL CPFF + ORNL	$411,000	

*ORNL costs include indirect.

Costs of Modifying Building 3517

The estimated costs of converting Cells 6, 7, 8, and 9 of Building 3517 to two manipulator cells suitable for incineration of high-level combustible wastes are presented in Table 6. The total cost is $850,000. This cost does not include operating cost or the cost of installing an incinerator. It is assumed that the existing process equipment has been removed and the cells decontaminated under funding provided by the AEC Division of Waste Management and Transportation.

Table 6. Estimated FPDL Modification Costs for High-Level Solid Waste Management

(Basis: FY 1974 Dollars)

Conversion of Process Cells 6, 7, 8, and 9, Building 3517 to Manipulator Cells

Item	Cost
Manipulators (4 pairs)	$100,000
Install manipulator windows (4)	200,000
Install Hg-vapor lighting	25,000
Install floor pans	20,000
Install waste load-in station	100,000
Install HEPA filters and fire sprinkler	35,000
Remove two partition walls	20,000
Remove service tunnel and Cell 17	25,000
Install additional shielding	25,000
Remove chilled water and reroute piping	10,000
Instrumentation	10,000
Design (20%)	112,000
Contingency (10%)	68,000
Total Modification Cost	$750,000
New transfer cask (β-γ-neutron)	100,000
GRAND TOTAL	$850,000

<u>Operating Costs For The FPDL Waste Management Complex.</u> The labor force will be deployed as required to handle low-level waste in Building 3505 and high-level waste in Building 3517. Operating costs of $400,000/year are detailed in Table 7.

Table 7. Operating Costs for ORNL Solid Waste Management

(Based on FY 1974 Dollars)

Item	Manyears	Cost
Chemical operators	12	$125,000
Process foreman	2	30,000
Overhead (80%)		120,000
Maintenance (Labor & overhead 157%)	2	50,000
Health Physics	1	30,000
Materials		15,000
Utilities		20,000
Contingency		10,000
TOTAL COSTS		$400,000

SUMMARY AND CONCLUSIONS

With the development of proper incineration equipment and a suitable method of encapsulating solid pieces of radioactive materials in an unleachable inorganic matrix, it will be possible to dispose of all the solid radioactive wastes generated at ORNL. The incinerator ash can be disposed of by incorporating it into a grout which is pumped into a fractured geological stratum ∿1000 ft below the water table. Encapsulated radioactive solid waste can be buried in auger holes at ORNL or, if necessary, shipped to a National Disposal Site. Finally, residual, high-level alpha-contaminated solid wastes can be placed in retrievable storage at ORNL or shipped to a National Disposal Site.

The Fission Product Development Laboratory, consisting of Buildings 3517 and 3505, can be modified to process all solid wastes generated at ORNL. Building 3517 can be used for high-level decontamination, for incinerating high-level combustible waste, for sorting and fragmenting high-level solid wastes, and for encapsulating high-level solid waste in a suitable matrix. Building 3505 can be utiilized for similar operations on low-level solid waste.

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